(RISK-2142) "The Monte Carlo Method for Modeling & Mitigating Systemic Risk"

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BIO of David Hulett

- Dr. David Hulett, FAACE, is a frequent contributor to AACE International conferences
- He is the principal author of two Recommended Practices and lead articles in Cost Engineering
- He has consulted and trained in project risk analysis, particularly quantitative schedule and cost risk analysis, as well as in scheduling, since 1990
- His clients are commercial and government agencies in North America, South America, Asia and Europe
- Something You Don't Know About Him: He loves choral and barbershop singing

BIO of Waylon Whitehead

- Waylon Whitehead has 15 years of experience on oil, gas, and chemical projects greater than $2 BUSD in value
- Experience divided between onshore and offshore, and with EPC and owner organizations
- He consults and trains internally with ConocoPhillips in scheduling and project risk analysis
- His clients are commercial and government agencies in North America, South America, Asia and Europe
- Something You Don’t Know About Him: Compared to Hulett, pretty much everything!

INTRODUCTION

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The Challenge to Monte Carlo Simulation

- Some within AACE have noted a supposed inability of Monte Carlo simulation (MCS) methods to represent systemic risks to project cost and schedule
- The claim is that the bottom-up approach of data collection in MCS-based analyses does not incorporate systemic risks
- This failing would be problematic given the large overruns in schedule and cost that can occur on mega-projects partially as a result of these risks

Response: that MCS can Incorporate Systemic Risk

- Systemic risks relate to the overarching issues such as:
  - Level of new technology
  - Degree of project definition
  - Project complexity
  - Project size
  - Organization's ability to manage large projects
- Systemic risks are viewed as different in principal from project-specific risks that are identified during risk data collection based on discussion with project team members and other SMEs
- This presentation shows how Monte Carlo simulation methods can incorporate systemic risks as well as uncertainty and project specific risks for an inclusive approach and result

Purpose of the Presentation

- We present a method of combining:
  - **Typical Monte Carlo Simulation methods**
  - **Representing uncertainty and project-specific risks**
  - **Including systemic risks**
  - **Using the Risk Drivers Methodology**
- We demonstrate the superiority of that approach for enabling effective mitigation
- The method requires:
  - **Use of a rich database of project results on comparable projects**
  - **Assessment of the likelihood that the systemic risks will apply to the project being analyzed**

RECENT DISCUSSIONS ABOUT SYSTEMIC RISK

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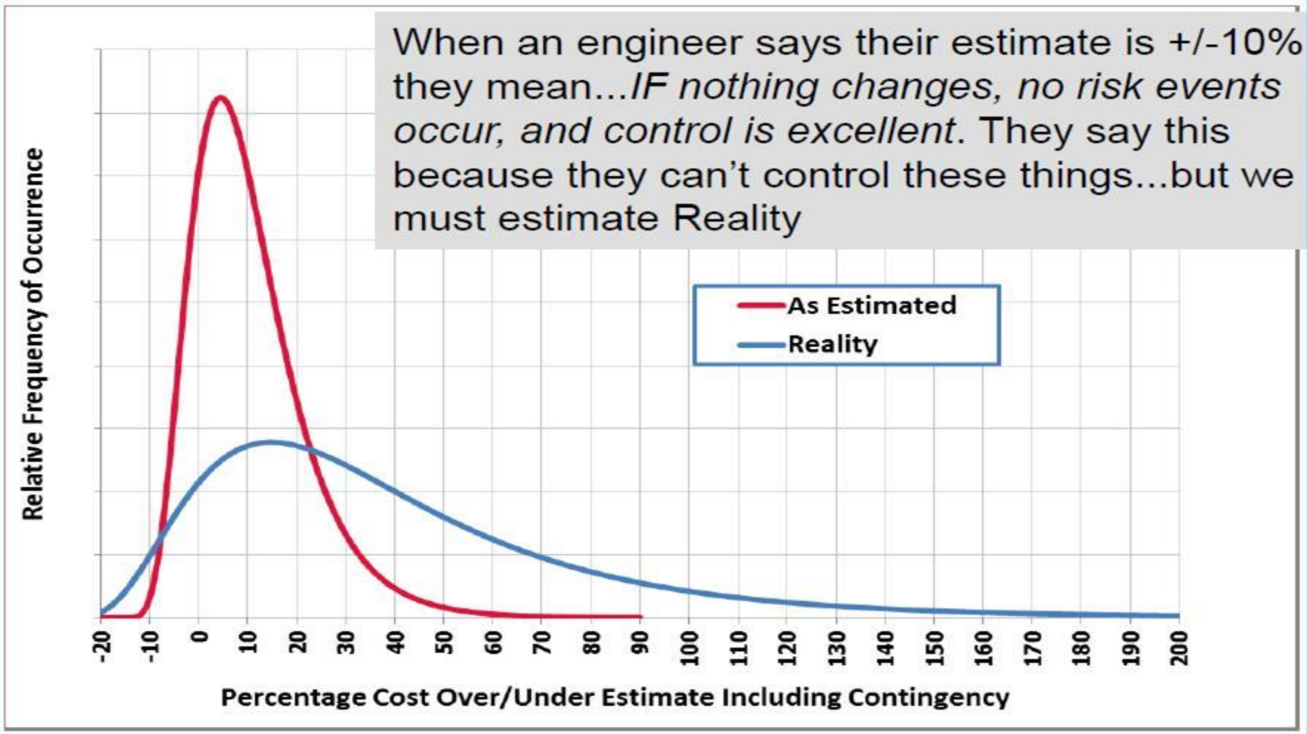
Project Cost Estimating and Reality

- John Hollmann has shown that project results from experience tend to be more pessimistic than estimates and risk assessments going in to the project [1]



Actual CPI Estimate Accuracy versus As Estimated; Large Projects

There is more information about cost overruns than about schedule overruns.
These are related, of course
This Presentation is focused on schedule overruns

- Ogilvie et. al., using the large database of process plant construction of Independent Project Analysis (IPA) have shown the same trends of overruns of cost compared to going-in estimates [2, also referenced in [1]]

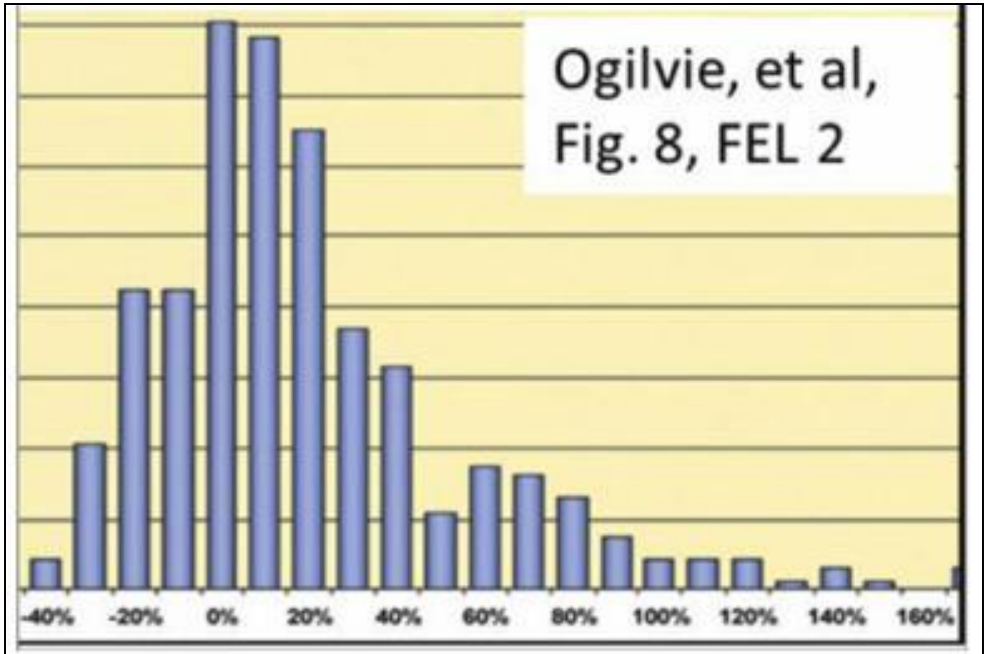


Figure 10—Tipping Point Model Versus Actual Growth Outcomes

There seems to be a serious chance of overrunning by 50% to 80% shown by the bi-modal distribution of actual results

APPROACH TO SCHEDULE RISK ANALYSIS USING MONTE CARLO SIMULATION

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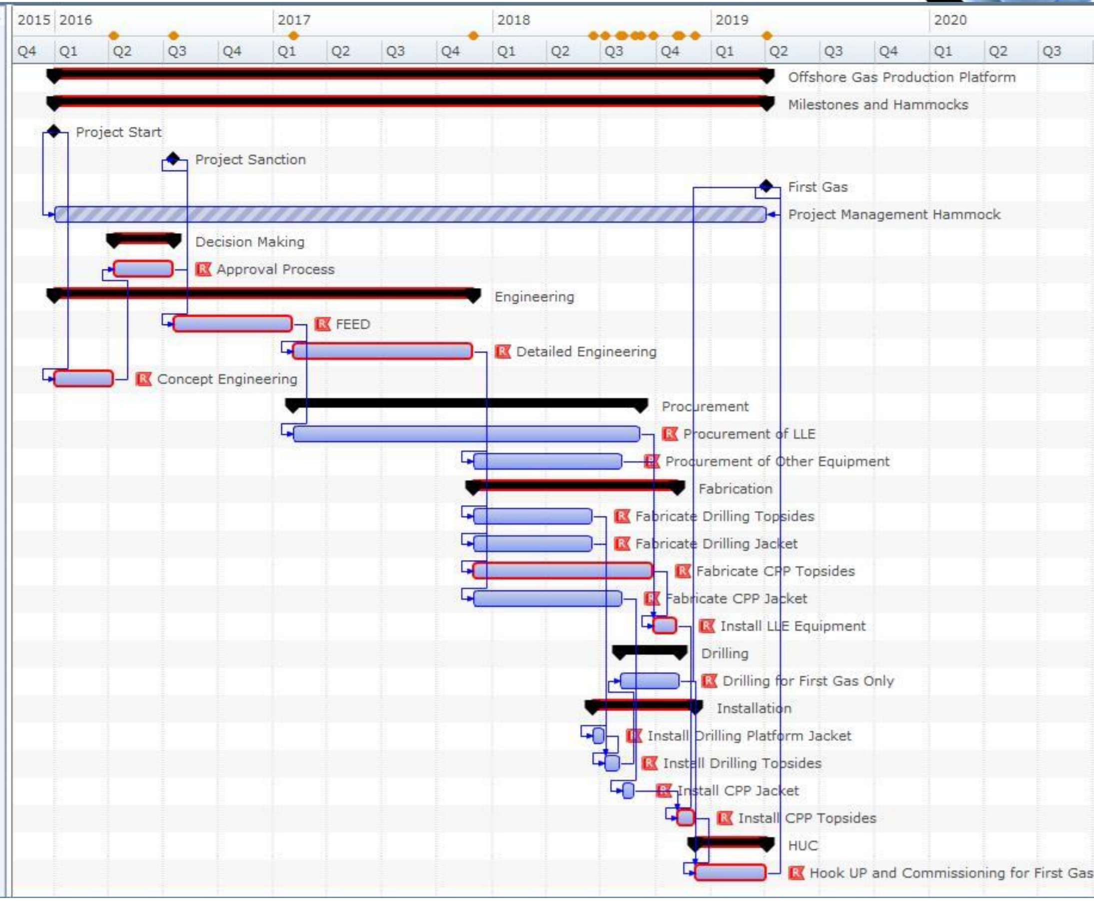
Components of the MCS Analysis

- Variation of project results compared to project plans generally include:
  - **Uncertainty, including inherent variation, estimating error and estimating bias**
  - **Project-specific risks**
  - **Systemic risks**
- This paper shows how these three types of risks are handled in a MCS approach to project schedule risk analysis
- A recent AACE International Recommended Practice dealt at length with the general method of MCS analysis applied to critical path method (CPM) schedules. [3]

Summary Schedule of a Megaproject

UID	Task	Start Date	End Date	Duration	Cost
Gas Platforr	▼ Offshore Gas Production Platfor	01/01/2016	04/04/2019	1,190	$1.717M
Gas Platforr	▼ Milestones and Hammocks	01/01/2016	04/04/2019	1,190	$400,000
A1000	Project Start	01/01/2016		0	$0
A1010	Project Sanction		07/18/2016	0	$0
A1020	First Gas		04/04/2019	0	$0
A1030	Project Management Ham	01/01/2016	04/04/2019	1,190	$400,000
Gas Platforr	▼ Decision Making	04/10/2016	07/18/2016	100	$8,000
B1000	Approval Process	04/10/2016	07/18/2016	100	$8,000
Gas Platforr	▼ Engineering	01/01/2016	11/30/2017	700	$256,000
C950	FEED	07/19/2016	02/03/2017	200	$80,000
C1010	Detailed Engineering	02/04/2017	11/30/2017	300	$160,000
C900	Concept Engineering	01/01/2016	04/09/2016	100	$16,000
Gas Platforr	▼ Procurement	02/04/2017	09/06/2018	580	$350,000
D1000	Procurement of LLE	02/04/2017	09/06/2018	580	$250,000
D1010	Procurement of Other Equ	12/01/2017	08/07/2018	250	$100,000
Gas Platforr	▼ Fabrication	12/01/2017	11/05/2018	340	$536,000
E1000	Fabricate Drilling Topsides	12/01/2017	06/18/2018	200	$80,000
E1010	Fabricate Drilling Jacket	12/01/2017	06/18/2018	200	$80,000
E1020	Fabricate CPP Topsides	12/01/2017	09/26/2018	300	$240,000
E1030	Fabricate CPP Jacket	12/01/2017	08/07/2018	250	$104,000
E1025	Install LLE Equipment	09/27/2018	11/05/2018	40	$32,000
Gas Platforr	▼ Drilling	08/03/2018	11/10/2018	100	$80,000
F1000	Drilling for First Gas Only	08/03/2018	11/10/2018	100	$80,000
Gas Platforr	▼ Installation	06/19/2018	12/05/2018	170	$47,200
G1000	Install Drilling Platform Ja	06/19/2018	07/08/2018	20	$8,000
G1010	Install Drilling Topsides	07/09/2018	08/02/2018	25	$13,600
G1020	Install CPP Jacket	08/08/2018	08/27/2018	20	$9,600
G1030	Install CPP Topsides	11/06/2018	12/05/2018	30	$16,000
Gas Platforr	▼ HUC	12/06/2018	04/04/2019	120	$40,000
H1000	Hook UP and Commission	12/06/2018	04/04/2019	120	$40,000

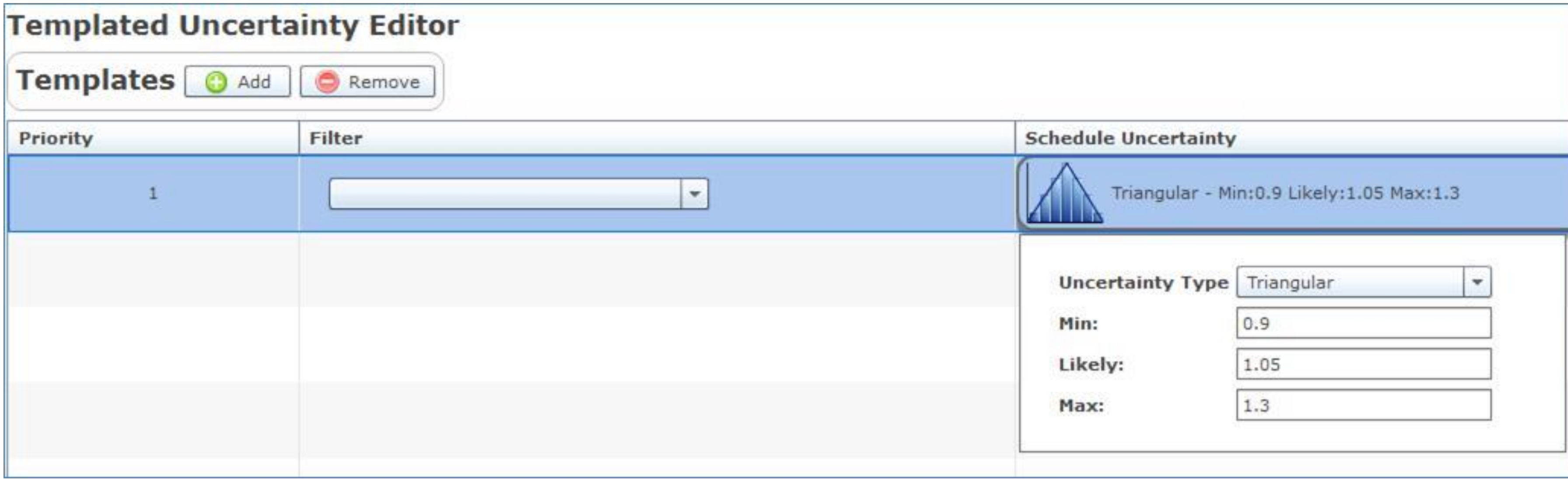


Offshore Gas Production Platform Construction Project
40 months duration, $1.7 billion
Schedule Driven Project

Add components of Risk - Uncertainty

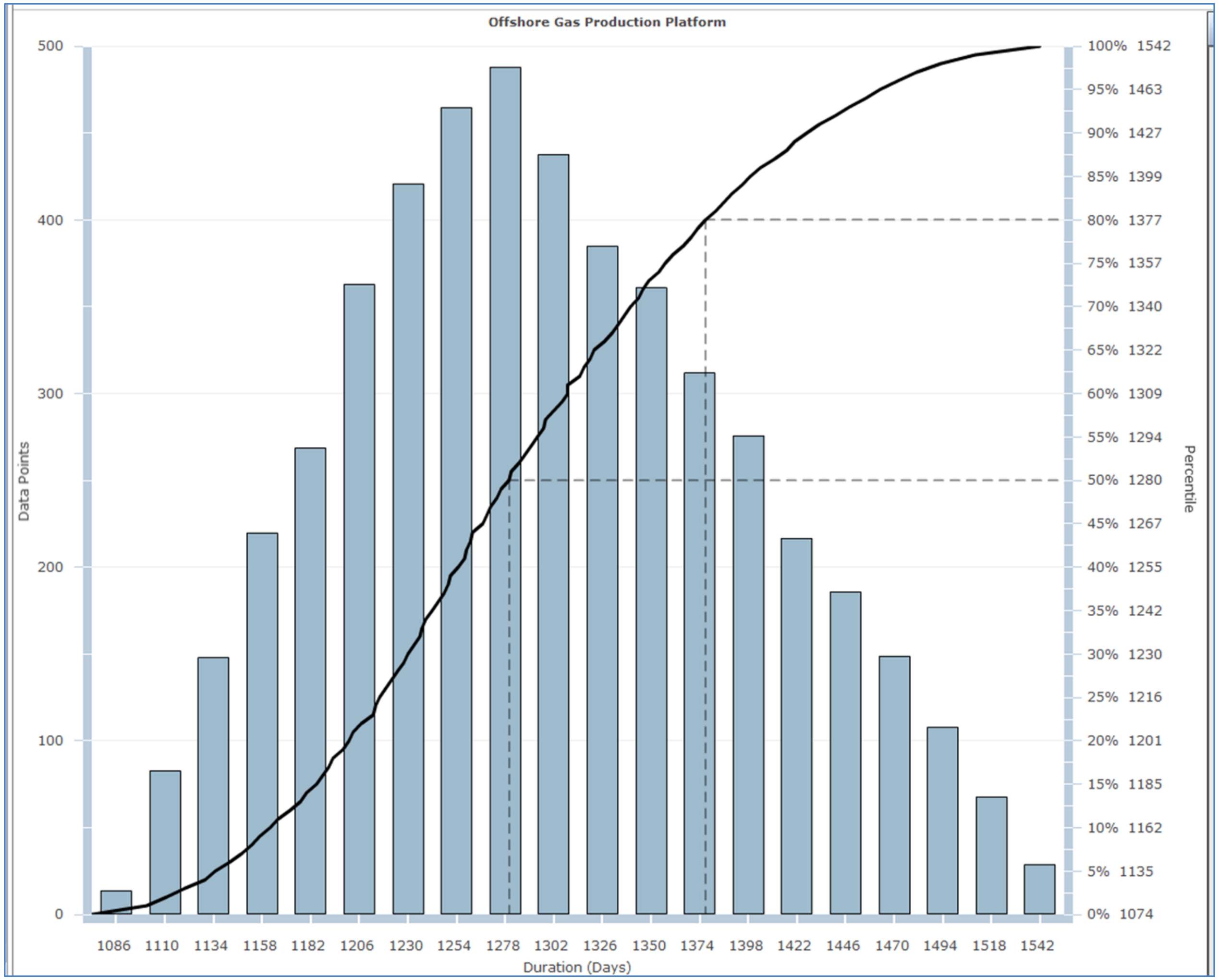
- Uncertainty is akin to "common cause" variation in the six sigma management
- "Common cause variability is a source of variation caused by unknown factors that result in a steady but random distribution of output around the average of the data. Common cause variation is a measure of the process's potential, or how well the process can perform when special cause variation is removed. ... Common cause variation is also called random variation, noise, non-controllable variation, within-group variation, or inherent variation." [4]

Specifying Uncertainty



Schedule Uncertainty range 90%, 105%, 130% applied to all activities
Uncertainty ranges can be applied to different types of activities as reference ranges
Uncertainty can be correlated

Schedule Risk with Uncertainty Only



Scheduled completion is April 4, 2019

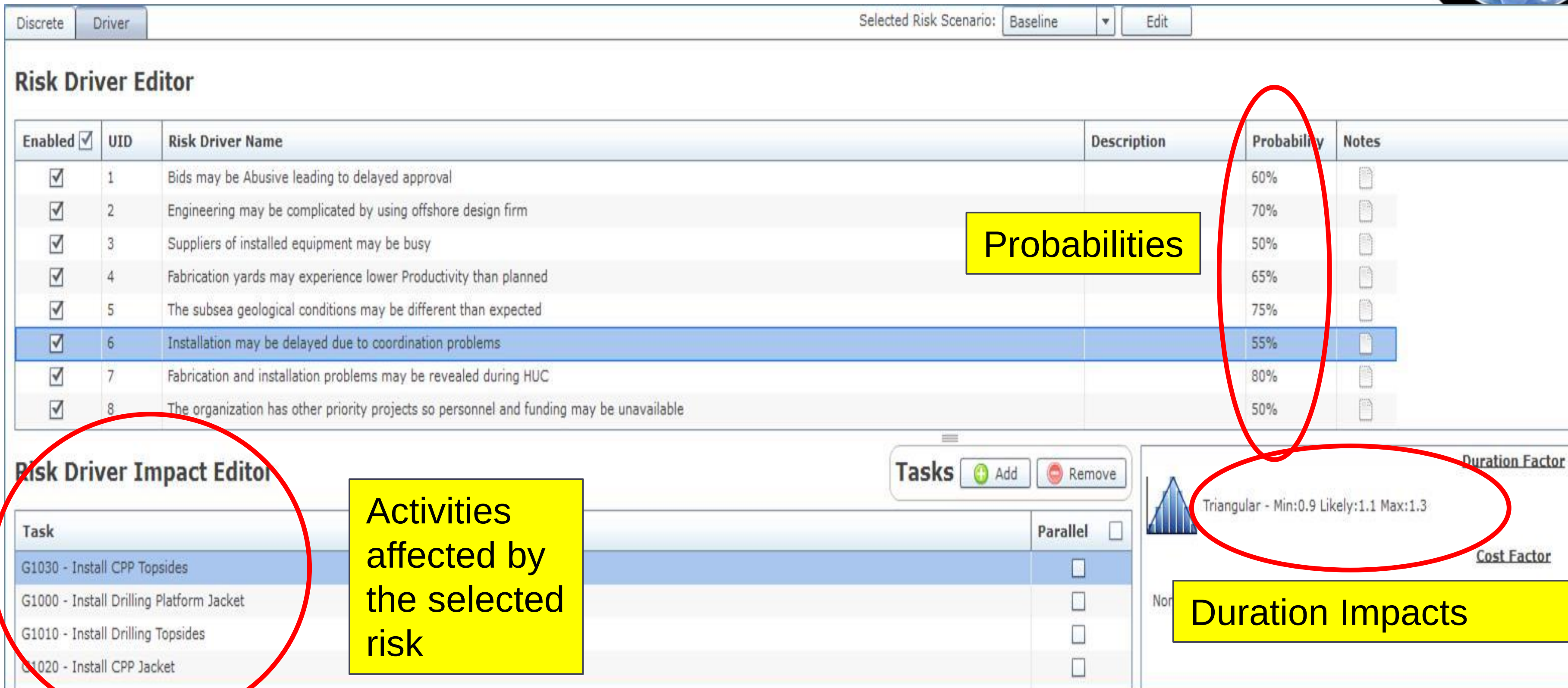
With Uncertainty Only the P-80 completion is October 10, 2019,

P-80 is at 1,377 working days, + 187 days or +16% of 1,190 in the schedule

Adding Project-Specific Risks

- Project Specific Risks are like special cause risk in the Six Sigma world
- "… Special cause variation is caused by known factors that result in a non-random distribution of output…Special cause variation is a shift in output caused by a specific factor such as environmental conditions or process input parameters. It can be accounted for directly and potentially removed..." [5]

Introducing Project-Specific Risks as Risk Factors

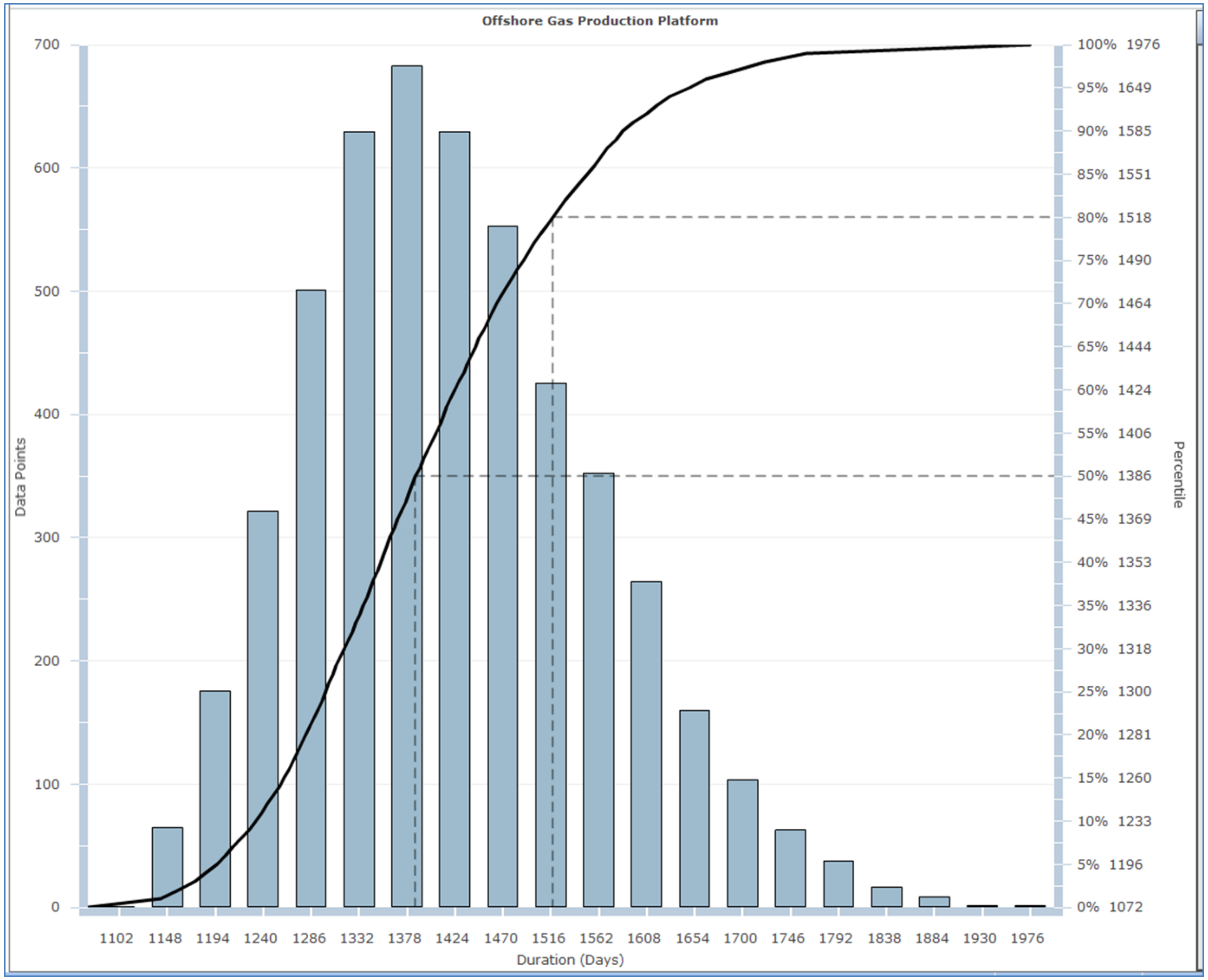


Here are 8 project-specific risks that are assigned to activities in the schedule

Some risks are assigned to several activities, some activities have several risks assigned

The risks are specified by probability and impact in multiplicative ranges. If they happen in an iteration the factor is chosen at random and multiplies the duration

Including Uncertainty and Project-Specific Risks



Scheduled completion is 1,190 working days

With Uncertainty Only the P-80 completion is October 10, 2019 and 16% overrun

With project-specific risks the P-80 is March 18, 2020, for an additional 5 months.

This is 1,518 days or +28%

ADDING SYSTEMIC RISKS

Typical Systemic Risks

- Level of new technology
- Degree of project definition
- Degree of process definition
- Project complexity including interdependence of project phases, components and actors
- Project size
- Project organization’s ability to manage large projects
- Planned engineering-construction overlap
- Aggressiveness of requirements
- Team cohesiveness and commonality of purpose
- Ability to maintain funding
- Labor Availability in closed markets (i.e. Australia, Alberta)

Factors adding Stress to the Project Success

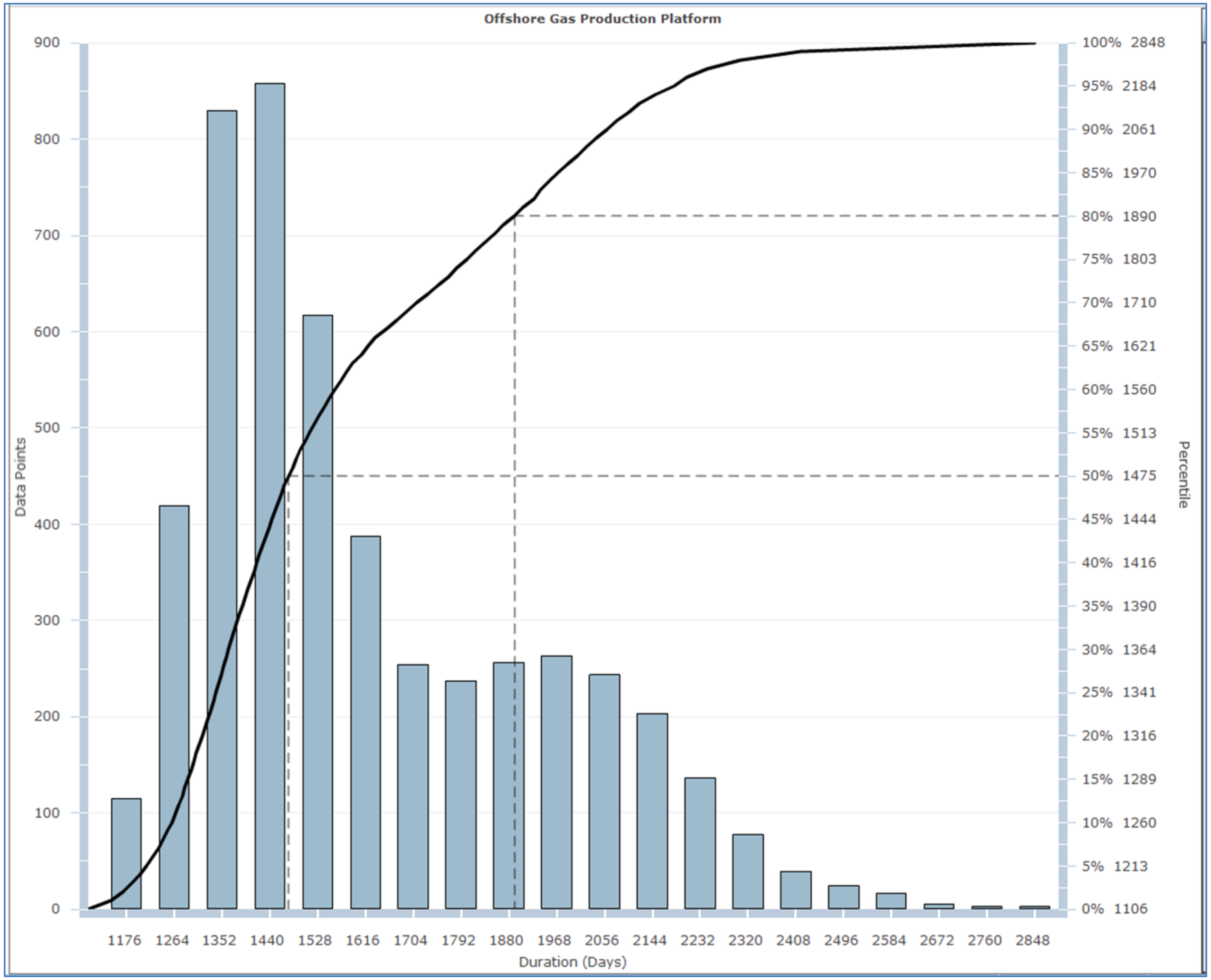
- Some factors can exacerbate the project at a systemic level
- One of these is schedule pressure
- Ed Merrow: “Schedule pressure dooms more megaprojects than any other single factor. When there is pressure to move a project along quickly from the outset, corners get cut and opportunists have a field day” [6]

Three Systemic Risks / Stressors Added

		Schedule Impact Multipliers		
Systemic Risk	Probability	Min	Most Likely	Max
The approach to the project is not well defined	10%	1.4	1.5	1.7
The project may use significant new technology	15%	1.4	1.45	1.6
Mega-project may have schedule pressure	8%	1.4	1.5	1.7

The Systemic Risks / Stressors are examples
Their probabilities of affecting this project are derived from the risk interviews
Their impacts should be derived from historical databases and risk interviews

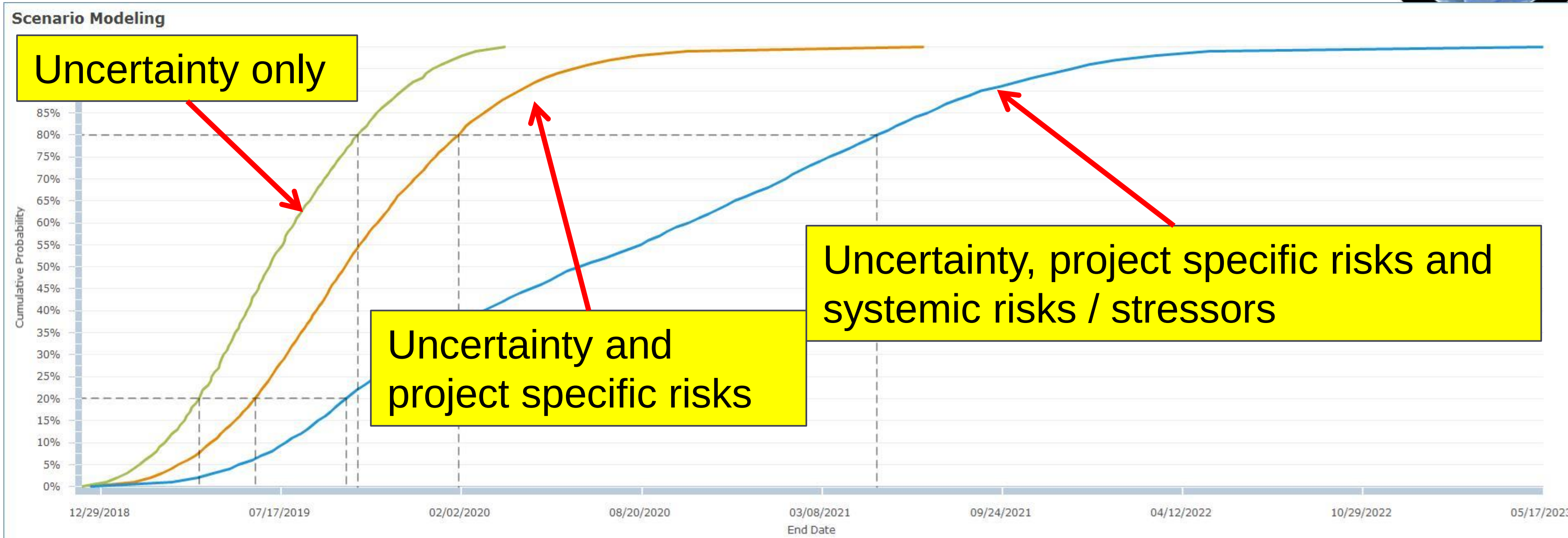
Results with Three Systemic Risks Added



With systemic risks added, the P-80 is now May 3, 2021. Systemic risks added ~ 19 months

The second mode is at 1,950 days which is 66% overrun on the scheduled 1,190 days

Compare the Three Scenarios



Task Data Add Remove | Measure: End Date | Chart Markers 70 % Add

Enabled		Name	Original	20%	80%
☑		Offshore Gas Production Platform UNCERTAINTY AND PROJECT SPECIFIC RISKS	04/04/2019	06/18/2019	01/30/2020
☑		Offshore Gas Production Platform UNCERTAINTY ONLY	04/04/2019	04/17/2019	10/10/2019
☑		Offshore Gas Production Platform, UNCERTAINTY, PROJECT-SPECIFIC AND SYSTEMIC RISKS	04/04/2019	09/27/2019	05/08/2021

The three scenarios show how much contingency systemic risks could add at P-80.

These are results using hypothetical data that illustrate possible historical data's information on impact combined with the project team's assessment of probability

PRIORITIZING RISKS FOR RISK MITIGATION

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Risk Prioritization Method

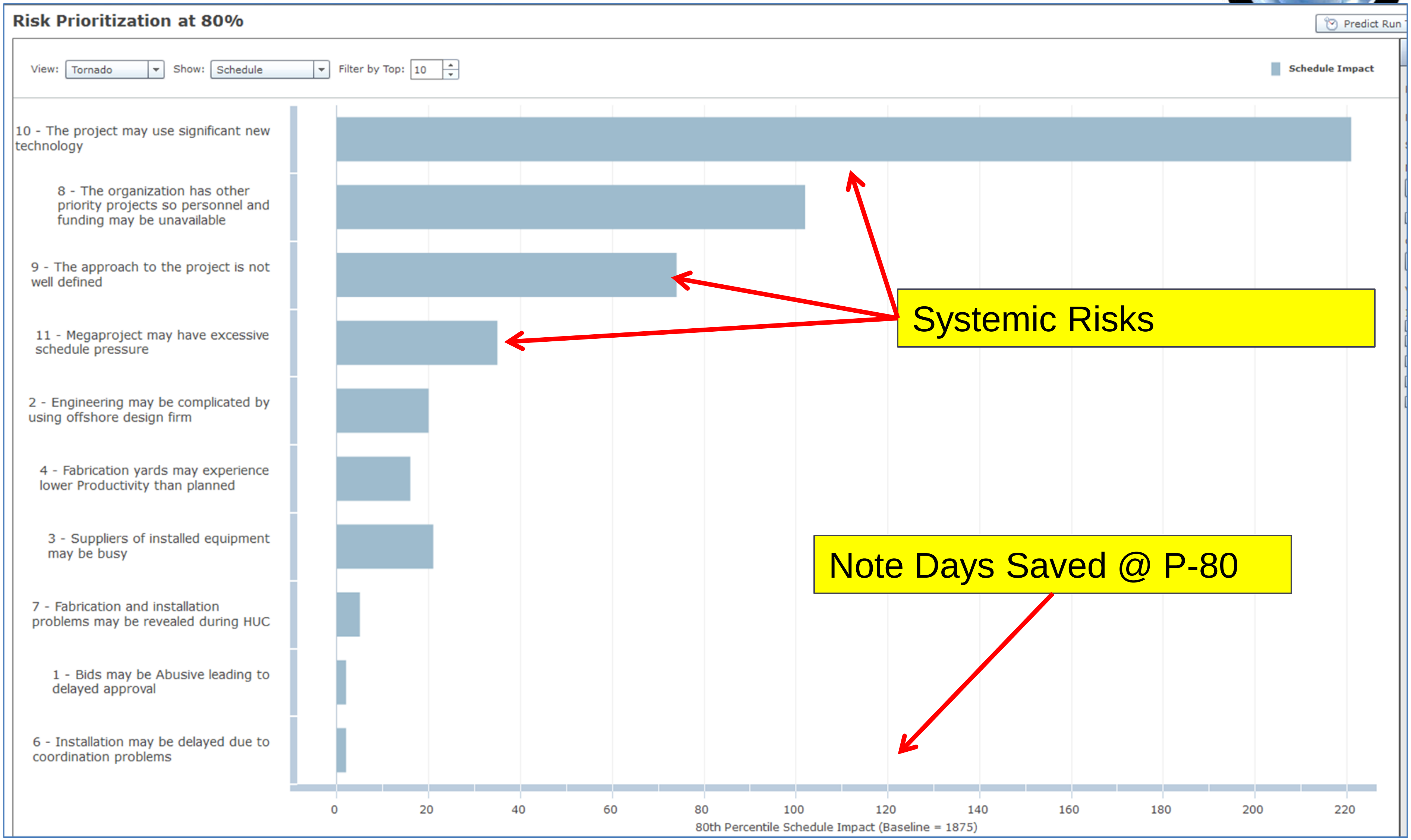
- Typical tornado diagrams have limitations:
  - **Report correlation coefficients, but management does not know how to turn these into actionable metrics**
  - **Correlation centers on the means of the distributions, but management cares about other targets, e.g., P-80**
  - **Usually report on activities, not risks, whereas management looks to mitigate risks**
  - **Even when they show correlation of risks with the finish date, the algorithm can show incorrect correlation leading to incorrect conclusions**

Preferred Prioritization Method

Iterative Approach to Prioritizing Risks (Days Saved at P-80)								
Risk #	1	2	3	4	5	6	7	8
Priority Level (Iteration #)	Abusive Bids	Offshore design firm	Suppliers Busy	Fab productivity	Geology unknown	Coordination during Installation	Problems at HUC	Resources may go to other projects
1	X	X	X	X	X	X	X	**1**
2	X	X	X	**2**	X	X	X	
3	X	**3**	X		X	X	X	
4	X		X		X	X	**4**	
5	X		**5**		X	X		
6	X				X	**6**		
7	**7**				X			
8					**8**			

Iterative prioritization method requires many simulations to order the risks correctly @ P-80 in Days Saved

Risk Prioritization Results



Risks, Systemic Risks and Uncertainty by Priority

UID	Name	Days Saved @ P-80
10	The project may use significant new technology	221
8	The organization has other priority projects so personnel and funding may be unavailable	102
9	The approach to the project is not well defined	74
11	Megaproject may have excessive schedule pressure	35
2	Engineering may be complicated by using offshore design firm	20
4	Fabrication yards may experience lower Productivity than planned	16
3	Suppliers of installed equipment may be busy	21
7	Fabrication and installation problems may be revealed during HUC	5
1	Bids may be Abusive leading to delayed approval	2
6	Installation may be delayed due to coordination problems	2
5	The subsea geological conditions may be different than expected	0
	Days saved by project-specific and systemic risks	498
	Days contributed by uncertainty	187
	Days contributed from risk combined with uncertainty	15
	Total Days Contingency @ P-80	700

RISK MITIGATION

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The 3 Questions of Risk Mitigation

- To mitigate risk we must answer 3 key questions:
  - **What should we do?**
  - **When must we do it?**
  - **Who must act?**

- Mitigation needs to go beyond a strategy
- The more specific the risk and the more tactical the mitigation, the more likely it is to be implemented
- The paper identifies the availability of labor in closed markets like Australia as a systemic risk and answering the 3 questions for this risk and it’s mitigations is insightful

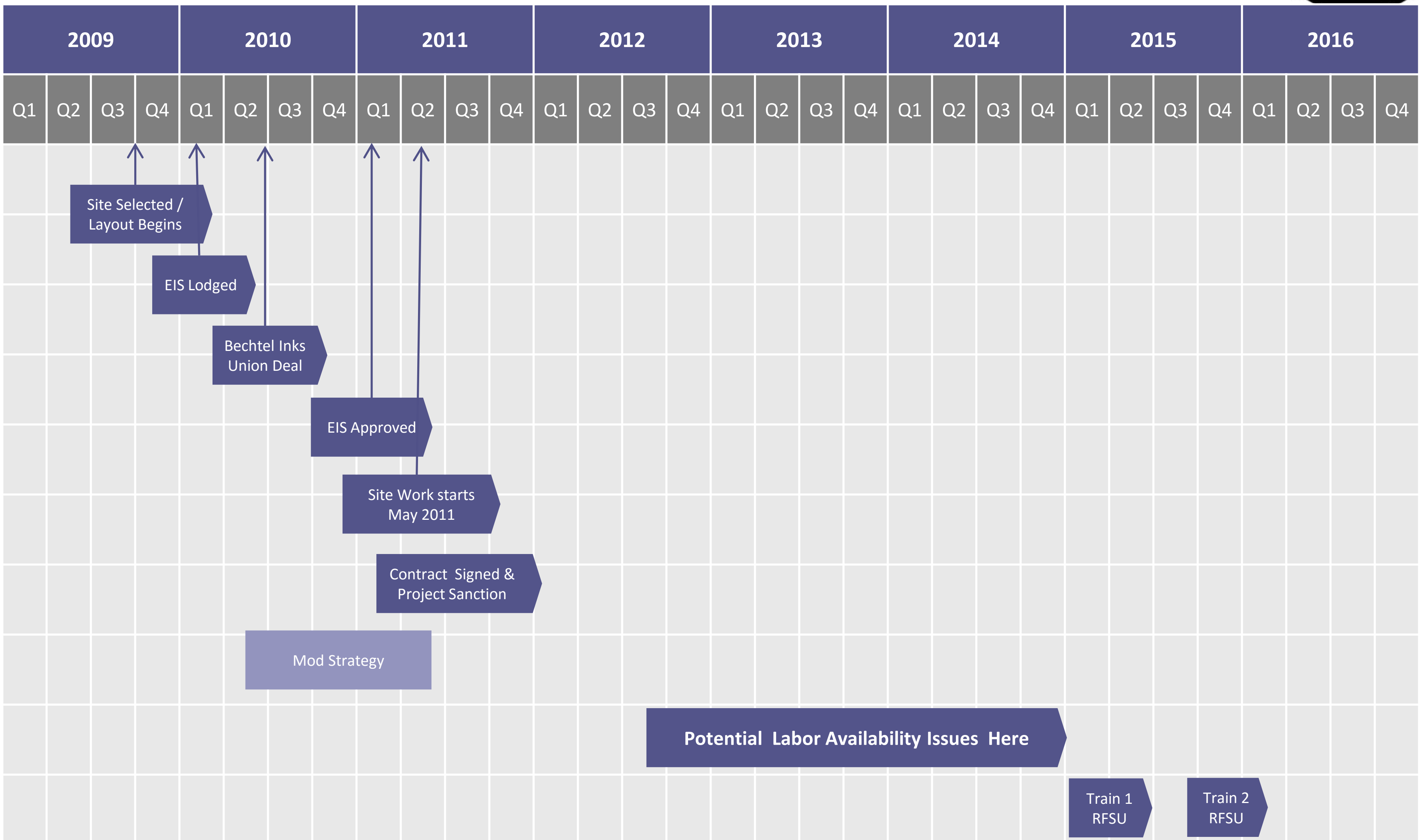
What will we do to solve the problem?

- For the labor availability risk, we took the following major actions to mitigate the risk:
  - **Modularized significant parts of the facility to remove work hours from the site in Australia**
  - **Awarded the LNG tank contract to a separate contractor with their own dedicated labor and supervision**
  - **Cost sharing provisions with EPC contractor to pay more to attract labor if we had to**
  - **Planned to pursue "block visas" for labor**

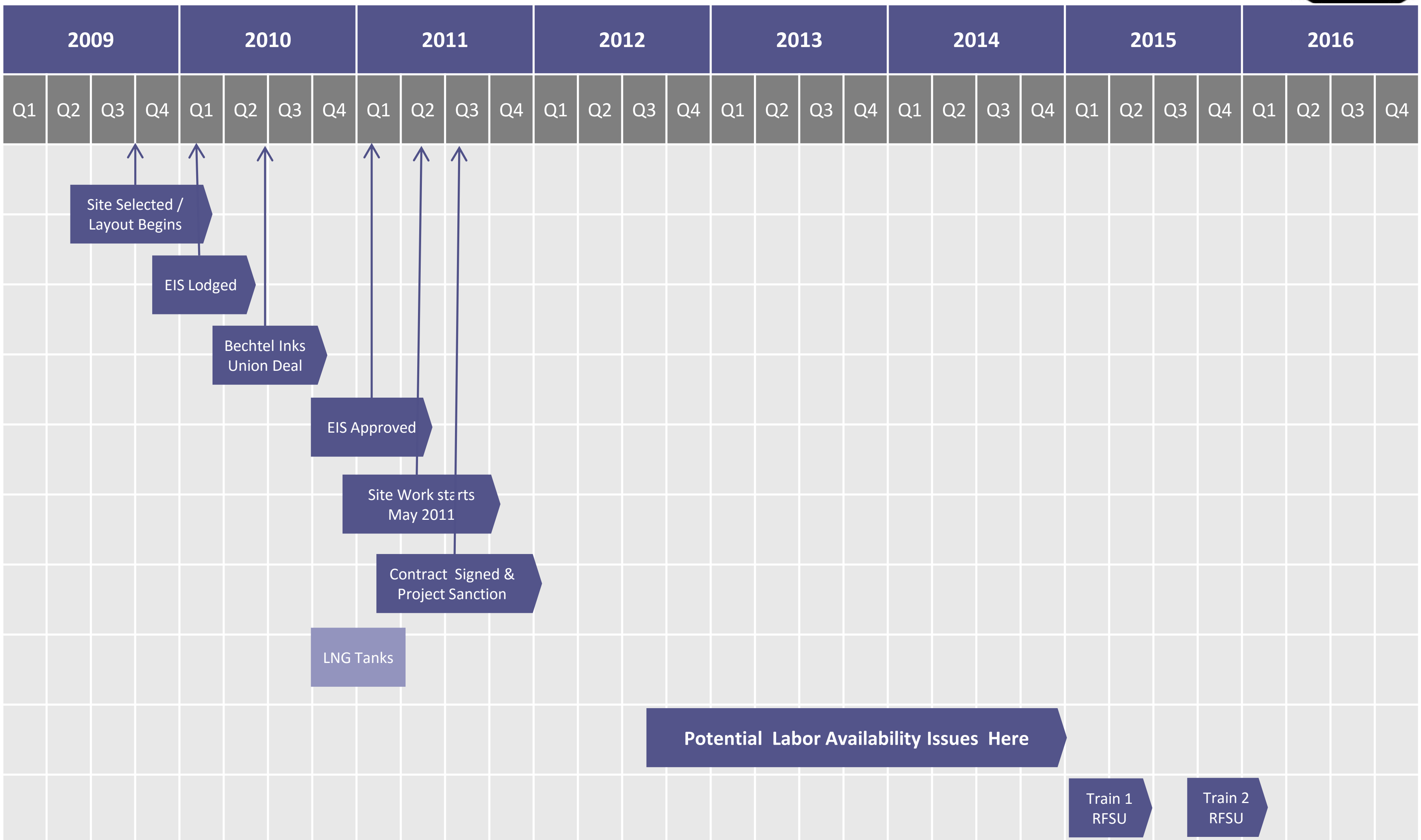
When must we act?

- Using the Risk & Mitigation Timeline for the risk and each major mitigation focuses attention on when the risk occurs and when the solution must be in place in order to be effective

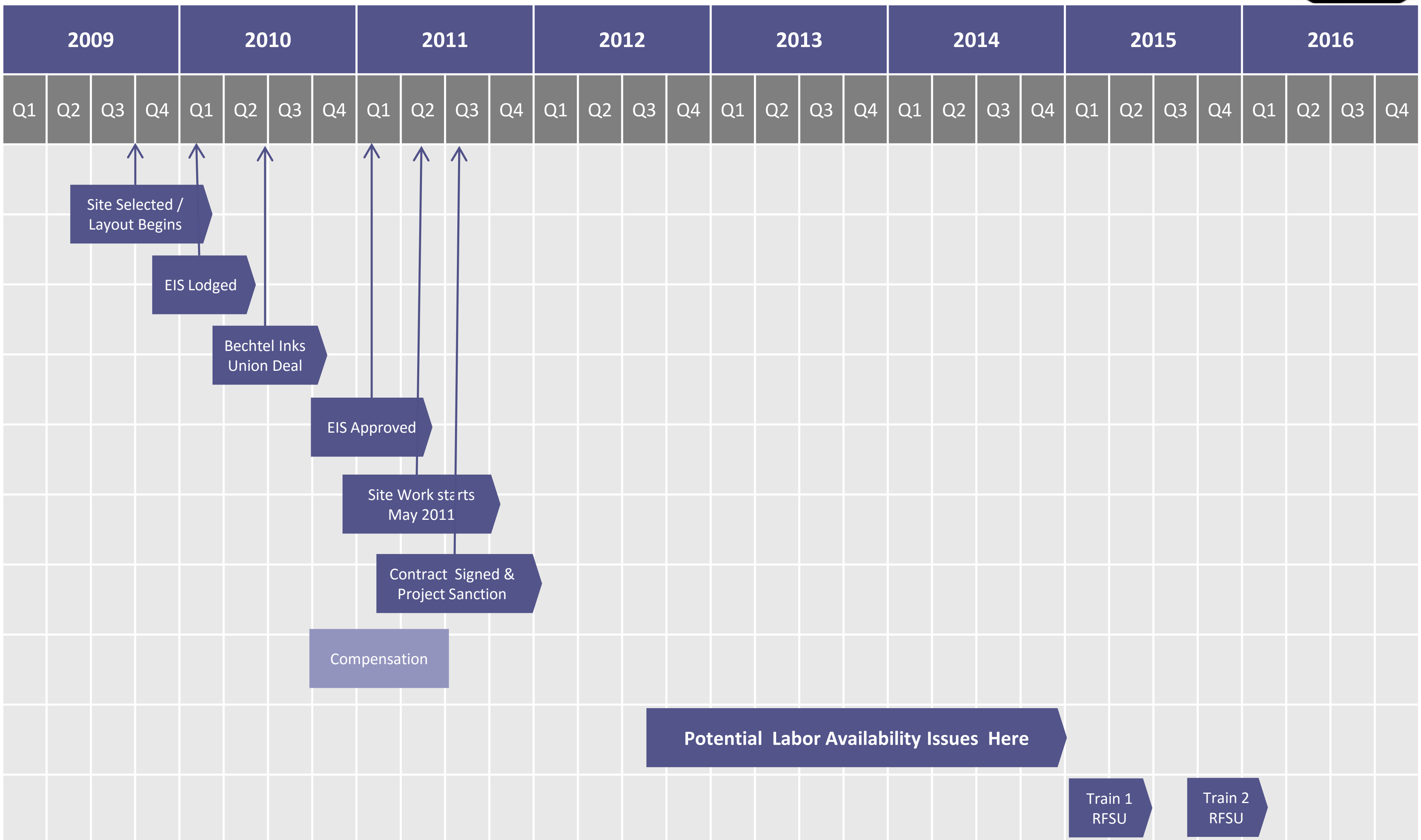
When – Modularization Strategy



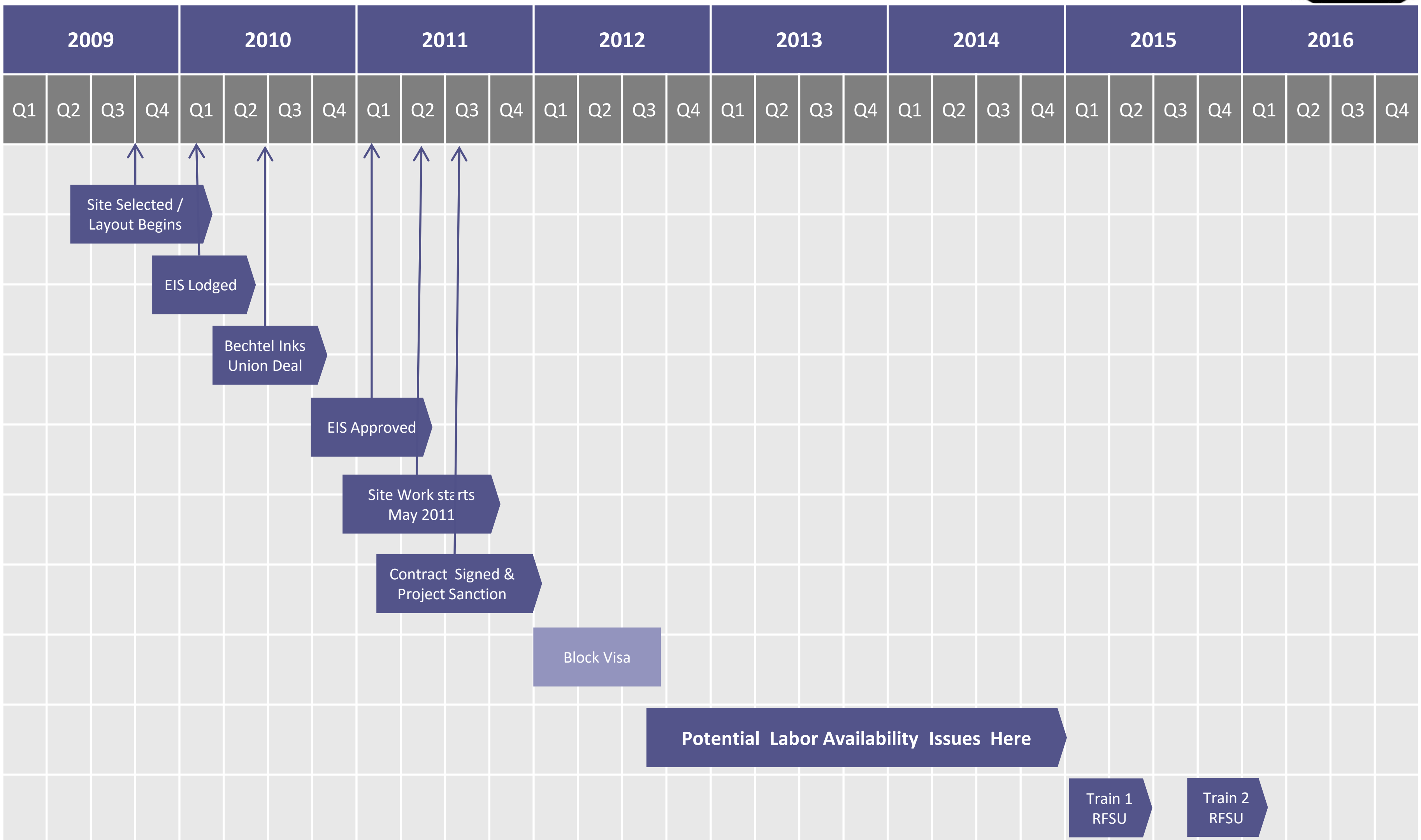
When – LNG Tank Award



When – Cost Sharing Provision in EPC Contract



When – Block Visas



Who Must Act?

- Who really "owns" the action for the mitigation? The paper discusses the tiered ownership of risk mitigation:
  - **Mitigation can be implemented wholly by the project team**
  - **It can be implemented by a broader group of stakeholders**
  - **Or it must be implemented by a party that is external and separate from the interests of the project**
- Understanding the tiers provides insight into the likely degree of success in implementing the mitigation

Who Must Act? – Modularization and LNG tanks

- The project team was able to make the determination to implement the modularization of parts of the facility and this mitigation was successfully implemented though the impact was difficult to assess
- The project team decided to separate the LNG tanks from the main EPC contract, the mitigation was successfully implemented and the tanks were completed on time

Who Must Act? – Cost Sharing and Block Visas

- The cost sharing provisions for paying more for labor were included in the EPC contract, however, implementation required the owner, EPC contractor, and labor unions to align. The provision was never exercised.
- Block visas (457 visa program) are written into the laws in Australia, so in theory, project willingness to exercise that mitigation should have been an available mitigation. In practice, this requires agreement from labor unions and legislative bodies and these impediments prevented this mitigation from ever being seriously pursued.

Successful Mitigation

- Answer the what, when and who of mitigation
- Develop the Risk & Mitigation Timelines for major risks and mitigations
- Segregate the mitigations into tiers of ownership
- Assess alignment of risk mitigation owners with the projects goals
- Do not count on success when the mitigation owners are truly external to the project
- Reassess periodically or at pre-defined trigger points

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7. Quotations from Secretary of Defense Donald Rumsfeld on “unknown unknowns” http://en.wikipedia.org/wiki/There_are_known_knowns

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